

# CLAIMS

5           1. An adaptive artificial vision method comprising the following steps:

          (a) defining successive couples of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) such that the time difference  $\tau$  between two synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) of a couple of synchronized timesteps is equal to  
10 a predetermined time delay  $\tau_0$ ,

          (b) comparing two successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) at each couple of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) spaced by said predetermined time delay  $\tau_0$  for obtaining a delta image  $\Delta_t$  which is the result of the computation of the distance between each pixel of said two  
15 successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) in view of characterizing movements of objects between said two successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ),

          (c) extracting features from said delta image  $\Delta_t$  for obtaining a potential dynamic patch  $P_t$  which is compared with dynamic patches previously recorded in a first repertory  $R_d$  which is progressively constructed  
20 in real time from an initial void repertory,

          (d) selecting the closest dynamic patch  $D_i$  in the first repertory  $R_d$  or if no sufficiently close dynamic patch still exists, adding the potential dynamic patch  $P_t$  to the first repertory  $R_d$  and therefore obtaining and storing a dynamic patch  $D_i$  from the comparison of two successive images  
25 ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) at each couple of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ), and

          (e) temporally integrating stored dynamic patches  $D_i$  of the first repertory  $R_d$  in order to detect and store stable sets of active dynamic patches representing a characterization of a reoccurring movement or event  
30 which is observed.

2. A method according to claim 1, wherein when stable sets of active dynamic patches representing a characterization of a reoccurring movement have been detected, the center of the movement is identified

and static patches which are at a predetermined distance  $d$  from the movement center and are obtained by a process of static pattern recognition are analyzed to constitute at a given timestep a set of active static patches  $S_i$  which are stored in a second repertory  $R_s$ .

5

3. A method according to claim 2, wherein stored static patches  $S_i$  of the second repertory  $R_s$  are spatially integrated in order to detect and store stable sets of active static patches representing a characterization of an object which is recurrently involved in observed known reoccurring movements.

10

4. A method according to claim 2 or claim 3, wherein the process of static pattern recognition and production of static patches is initiated after stable sets of active dynamic patches representing a characterization of a reoccurring movement have been detected.

15

5. A method according to claim 2 or claim 3, wherein the process of static pattern recognition and production of static patches is initiated at the same time as the process of dynamic movement recognition and production of dynamic patches and when stable sets of active dynamic patches representing a characterization of a reoccurring movement have been detected, the process of static pattern recognition is continued exclusively with static patches which are located in a restricted area of the image which is centered on said identified movement center.

20

6. A method according to anyone of claims 1 to 5, wherein during the computation of the distance between each pixel of two successive images  $(I_{t-1}, I_t)$ , a filter function  $f_{th}$  is used to keep only the most significant differences and therefore obtain a delta image  $\Delta_t$  such that

25

$$\Delta_t = f_{th} ( || (I_{t-1}, I_t) || )$$

30

7. A method according to claim 6, wherein the filter function  $f_{th}$  is a threshold function.

8. A method according to anyone of claims 1 to 7, wherein the step of extracting features from the delta image  $\Delta_t$  comprises computing a gaussian color model of the distribution for each color component.

5           9. A method according to anyone of claims 1 to 7, wherein the step of extracting features from the delta image  $\Delta_t$  comprises using histograms to model the distribution for color components, shape or texture.

10           10. A method according to anyone of claims 2 to 5, wherein static patches are obtained on the basis of salient points  $(x,y)$  in an image  $I_t$  provided at a synchronized timestep  $t$  when a salient point  $(x,y)$  is detected, a region  $R_{x,y}$  corresponding to the surrounding pixels is defined and features are extracted from this region  $R_{x,y}$  to define a potential static patch  
15     $S_{x,y}$ .

          11. A method according to claim 10, wherein the extraction of features from the region  $R_{x,y}$  comprises measuring the color change of a pixel compared to its neighbors and computing a color model of the color  
20    distribution in the region  $R_{x,y}$ .

          12. A method according to anyone of claims 1 to 11, wherein successive steps of synchronized timesteps  $(t_1, t; T+t_1; T+t; \dots)$  are separated by a period of time  $T$  which is equal to  $\underline{n}$  times the  
25    predetermined time delay  $\tau_0$ , where  $\underline{n}$  is an integer which is positive or equal to zero.

          13. A method according to claim 12, wherein successive couples of synchronized timesteps  $(t_1, t; t, t_{+1}; \dots)$  are contiguous without any time  
30    interruption between two successive couples of synchronized timesteps  $(t_1, t; t, t_{+1})$ .

          14. A method according to anyone of claims 1 to 13, wherein it further comprises the step of detecting transitions between stable sets of  
35    active dynamic patches representing a characterization of reoccurring

movements and of constructing transition graphs for predicting complex events comprising a sequence of identified movements.

15. An adaptive artificial vision system comprising:

5           - a clock (101) for defining successive couples of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) such that the time difference  $\tau$  between two synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) of a couple of synchronized timesteps is equal to a predetermined time delay  $\tau_0$ ,

10           - inputting means (102) for inputting images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) provided by a camera (103) at said synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ),

15           - first comparator means (104) for comparing two successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) inputted at each couple of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ) spaced by said predetermined time delay  $\tau_0$  for obtaining a delta image  $\Delta_t$  which is the result of the computation of the distance between each pixel of said two successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ),

20           - first memory means ( $M_d$ ) for storing dynamic patches  $D_i$  representing elementary visual parts for describing characterized movements of objects,

            - feature extraction means (105) for extracting features from said delta image  $\Delta_t$  and producing a potential dynamic patch  $P_t$ ,

25           - second comparator means (106) for comparing a potential dynamic patch  $P_t$  which is compared with dynamic patches previously recorded in said first memory means ( $M_d$ ),

30           - selection means (107) for selecting the closest dynamic patch  $D_i$  in the first memory means ( $M_d$ ) or if no sufficiently close dynamic patch still exists, for recording the potential dynamic patch  $P_t$  into the first memory means so that a dynamic patch  $D_i$  is stored in the first memory means for each comparison of two successive images ( $I_{t-1}, I_t; I_t, I_{t+1}, \dots$ ) at each couple of synchronized timesteps ( $t_{-1}, t; t, t_{+1}; \dots$ ),

            - first temporal integration means (108) comprising computing means (108A) for computing during a time  $T_{F1}$  corresponding to a

predetermined number  $N1$  of couples of synchronized timesteps the frequency of each dynamic patch  $D_i$  stored in the first memory means and threshold means (108B) for defining a set of active dynamic patches comprising dynamic patches  $D_i$  whose frequency is higher than a  
 5 predetermined threshold, and,

- second temporal integration means (107) comprising computing means (109A) for computing during a time  $T_{F2}$  corresponding to a predetermined number  $N2$  of couples of synchronized timesteps the frequency of each set of defined active dynamic patches and threshold  
 10 means (109B) for defining a stable set of dynamic patches corresponding to a reoccurring movement for each set of active dynamic patches whose frequency is higher than a predetermined threshold.

16. A system according to claim 15, wherein it further comprises  
 15 means (110) for identifying the center of a reoccurring movement represented by a stable set of active dynamic patches and means (111) for triggering static pattern recognition (112) for analyzing static patches which are at a predetermined distance  $d$  from said center of a reoccurring movement.